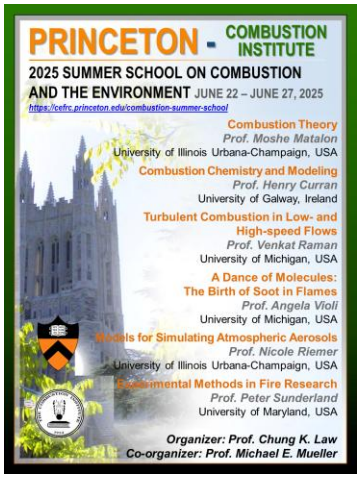

Our Mission

To provide the next generation of combustion researchers with a comprehensive knowledge in the technical areas of combustion theory, chemistry, experiment, computation and applications.

The 2025 Session

The 2025 **Princeton-Combustion Institute Summer School on Combustion and the Environment**, scheduled for **June 22 to June 27, 2025,** will offer the following courses: (1) Combustion Theory; (2) Combustion Chemistry and Modeling; (3) Turbulent Combustion in Low- and High-speed Flows; (4) A Dance of Molecules: The Birth of Soot in Flames; (5) Models for Simulating Atmospheric Aerosols; and (6) Experimental Methods in Fire Research.

Application Materials

Submit application at https://cefrc.princeton.edu/combustion-summer-school by March 14, 2025. Acceptance will be communicated by April 5, 2025.

Program Dates

Arrival & Welcome Dinner: Sunday, June 22, 2025; dinner at 6:30pm
Class Schedule: Monday, June 23, to Friday, June 27, 2025
Celebration & Farewell Banquet: Thursday, June 26, 2025
Departure/Check Out: Friday, June 27, 2025

Course Description

Combustion Theory (Monday-Friday; AM)
Lecturer: **Prof. Moshe Matalon**, University of Illinois at Urbana-Champaign, USA

This course provides an introduction to the theoretical foundations of combustion science. The aim is to develop an understanding of the basic principles associated with various combustion processes, how these concepts relate to experimental observations and how they can be used for theoretical and/or numerical modeling. It starts with a comprehensive overview of the mathematical equations that describe the flow of multi-component, chemically-reacting mixtures and covers various topics including the structure of premixed and diffusion flames, ignition and extinction phenomena, effects of flame stretch and differential diffusion, lifted diffusion flames and edge flames, burning of condensed fuels and spray combustion, intrinsic flame instabilities, and turbulent flames.

Combustion Chemistry and Modeling (Monday-Friday; PM)
Lecturer: **Prof. Henry Curran**, NUI Galway, Ireland

This course introduces the development of detailed chemical kinetic mechanisms to describe the oxidation of hydrocarbon and oxygenated hydrocarbon fuels and ammonia. It includes a tutorial on the importance of thermochemistry and the use of group additivity to estimate/calculate thermodynamic parameters for species using the THERM program. There will be a detailed discussion on the important general classes of reactions associated with fuel oxidation and the calculation/estimation of the important rate constants associated with these reactions. The importance of good experimental data which are used as validation targets will also be discussed.

Turbulent Combustion in Low- and High-speed Flows (Monday-Wednesday; PM)
Lecturer: **Prof. Venkat Raman**, University of Michigan, USA

Turbulence is an important characteristic of flame processes in practical systems. The role of this complex phenomenon on flame behavior controls the design, robustness, and performance of modern propulsion and energy conversion systems. This course will focus on the basics of turbulence, its impact on combustion and flame processes, and its application to gas turbines, scramjets, and the emerging field of rotating detonation engines. The use of modern high-performance computing tools and their role in altering the modeling needs will be discussed.

2025 Princeton-CI Summer School on Combustion and the Environment

Visit us online at https://cefrc.princeton.edu/combustion-summer-school. Further inquiries on the academic program may be made by contacting cefrc1@princeton.edu.

Course Description (continued...)

A Dance of Molecules: The Birth of Soot in Flames (Monday-Wednesday; AM)

Lecturer: **Prof. Angela Violi**, University of Michigan, USA

From wildfires to vehicle exhaust, soot particles significantly impact our climate and air quality. This lecture series explores the molecular mechanisms of soot formation in combustion systems and investigates mitigation strategies. We begin with the fundamental principles of soot formation during hydrocarbon combustion, highlighting its crucial role in climate change and air pollution. We then delve into the world of molecular interactions employing molecular dynamics (MD) simulations to visualize and understand the complex processes within flames. This section will also introduce foundational machine learning (ML) concepts which can be applied to analyze combustion data and identify key reaction pathways. Participants will gain hands-on experience with both MD simulations and basic ML techniques.

Models for Simulating Atmospheric Aerosols (Thursday-Friday; AM)

Lecturer: **Prof. Nicole Riemer**, University of Illinois at Urbana-Champaign, USA

This course provides an overview of atmospheric aerosol modeling and its critical role in air quality and climate simulations. Topics include the aerosol life cycle, with a focus on formulating governing equations for key processes, and a comparison of numerical discretization techniques used in state-of-the-art applications. Strategies for model verification, validation, and addressing structural and parametric uncertainties will also be discussed. Practical examples highlight how these approaches capture the complex physical and chemical transformations of aerosols and their impacts on weather, climate, and human health.

Experimental Methods in Fire Research (Thursday-Friday; PM)

Lecturer: **Prof. Peter Sunderland**, University of Maryland, USA

Many of the fuels, flames, and diagnostics associated with fire research are different from those that are common in combustion. The condensed fuels and optically-thick flames in many fires result in unusual experimental challenges. Recent research will be presented on pyrometry of embers, thin filaments, and soot, as well as fires involving firebrands, microgravity, refrigerants, and hydrogen. Several key fire standards will be discussed, including flash point, smoke chamber, cone calorimeter, cup burner, LIFT, and downward spread. Emerging topics in fire research will be introduced, including battery fires.

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